Center Independent Research & Development: LaRC IRAD

Plasma Spray Synthesis of High Purity Boron Nitride Nanotubes

Completed Technology Project (2013 - 2014)

Project Introduction

The objective of this project is the efficient synthesis of high quality boron nitride nanotubes (BNNT's) using the LaRC radio frequency plasma spray (RFPS) facility. Efficient synthesis implies large quantities via a reliable and readily-scalable process. High quality infers a product of high purity with an abundance of defect-free, small diameter nanotubes.

Compared with carbon nanotubes, BNNT's possess better mechanical properties and are thermally stable to much higher temperatures. The potential benefits of BNNT-reinforced structural materials can only be explored if commercial quantities of high purity, low defect BNNT's are available to the aerospace industry. The majority of nanotube production for structural composires is focused on generating 'yarn' for continuous reinforcement of polymer-based matrices. The goal of this effort is to synthesize relatively short 'fibers' for discontinuous reinforcement of metal- or ceramic-based matrices.

A novel combination of the RFPS process with a chemical reaction chamber for rapid, in-situ synthesis is envisioned. The effort will draw on extensive work performed in Russia during the 1980's (Tumanov, et al.). Their nuclear industry developed 'plasma-chemical synthesis' of nano-sized powders of metal oxides, carbides and nitrides. The lack of consumable electrodes and the confined environment characteristic of RFPS offer big advantages over the DC and atmospheric plasma techniques employed in the prior work. It is anticipated that the approach will yield abundant quantities of high purity nanotubes of the order of 10 microns long. A goal will be to separate single- and multi-walled species during the process.

Anticipated Benefits

It is recognized that the exceptional mechanical and physical properties exhibited by BNNT's will be hard to exploit in structural composites. For example, the highest strengths quoted for CNT's are impressive, but are applicable to short, defect-free nanotubes only. In reality, the creation of kinks (joints) is inherent to the nanotube growth process. Such joints are unavoidable and the maximum attainable strength decreases with nanotube length as a result. However, long, discontinuously-reinforced composites only require a fiber aspect ratio of ~10,000 to deliver high tensile strength to the matrix. Consequently, 1 nm diameter nanotubes only need to be ~ 10 ?m long to provide effective reinforcement in metallic-, ceramic- or polymeric-based materials

Fibers, yarns, and woven fabrics of BNNTs can be inserted into hybrid, laminate and composite materials by applying RFPS processing technology. Post-processing will permit the stiffness, strength, and toughness of BNNT's to

Project Image Plasma Spray Synthesis of High Purity Boron Nitride Nanotubes

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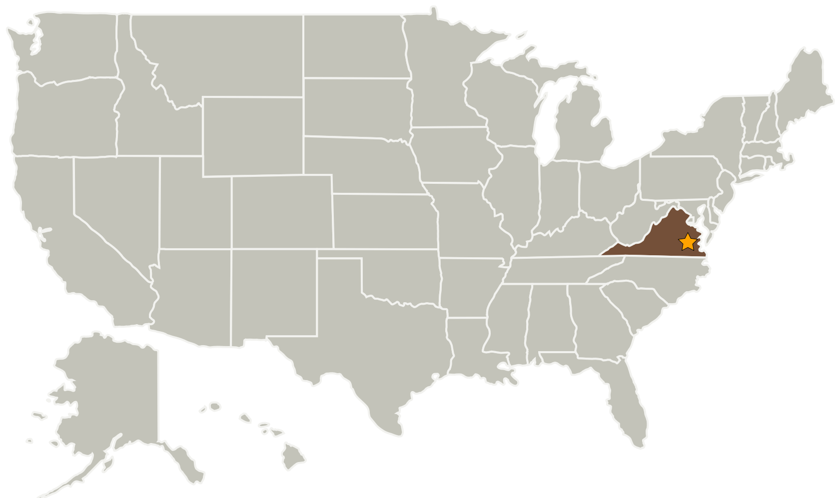
be exploited. The tailored lay-ups afforded by this fabrication approach will enable a suite of mechanical and physical properties to be realized in the final product. Lightweight, BNNT-containing materials may be employed in many primary and secondary aircraft structures. A planned follow-on to this study will involve direct deposition and/or secondary processing to incorporate BNNT's within FML materials

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Langley Research Center(LaRC)	Lead Organization	NASA Center	Hampton, Virginia

Primary U.S. Work Locations
Virginia

Organizational Responsibility

Responsible Mission Directorate:

Mission Support Directorate (MSD)

Lead Center / Facility:

Langley Research Center (LaRC)

Responsible Program:

Center Independent Research & Development: LaRC IRAD

Project Management

Program Manager:

Julie A Williams-byrd

Project Manager:

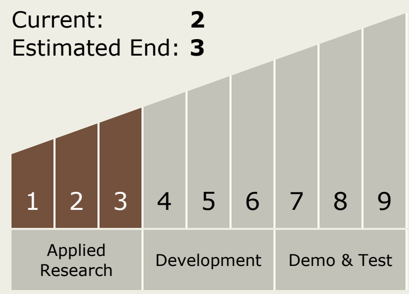
Stephen J Hales

Principal Investigator:

Stephen J Hales

Technology Maturity (TRL)

Start: **1**
Current: **2**
Estimated End: **3**



Images

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Project Image Plasma Spray Synthesis of High Purity Boron Nitride Nanotubes
(https://techport.nasa.gov/image/2289)

Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  - └ TX12.1 Materials
    - └ TX12.1.1 Lightweight Structural Materials